CITRUS

Vol I.

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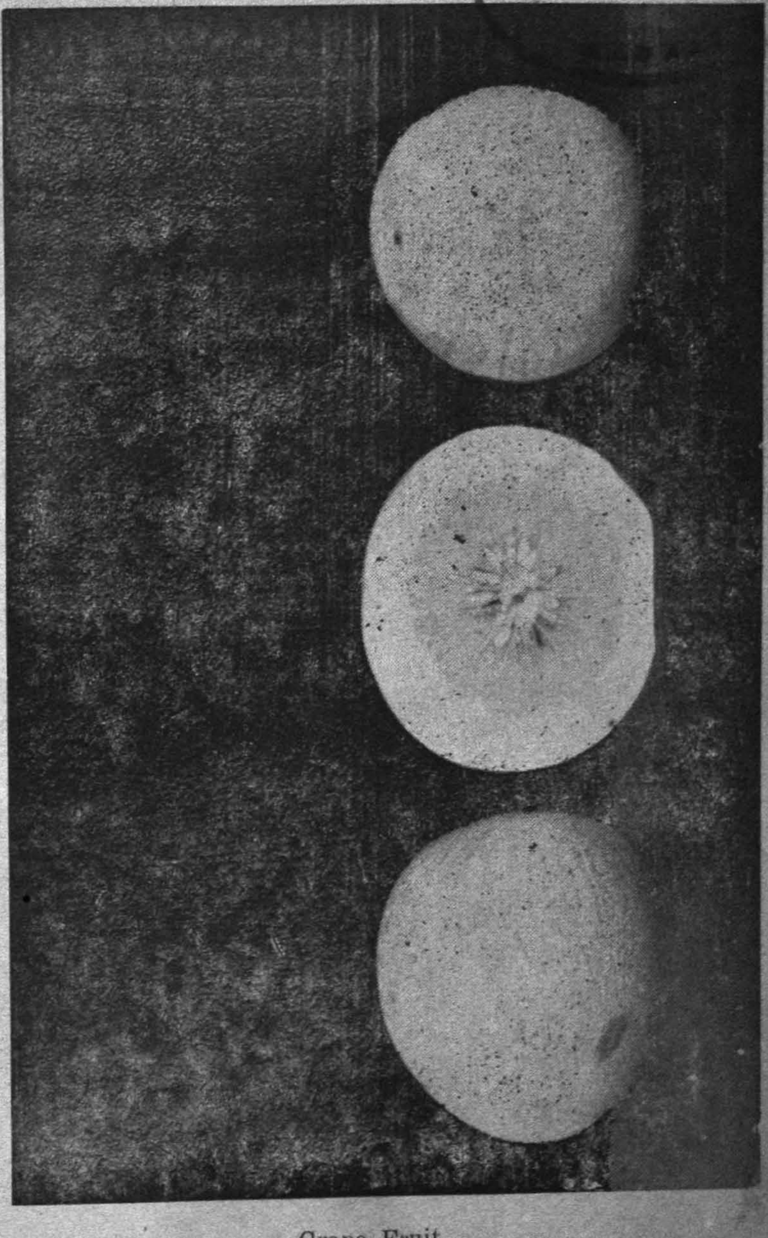

Grape Fruit

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Pommello (Chakothra)

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CITRUS

Vol. I.

We sow seed and the plant grows and bears fruit. It is a natural phenomenon. The fruit grower, however, expects his plants to grow well and yield fruit in abundance and of good quality. To achieve this, certain impediments have to be overcome.

Climate:

The climatic factors that determine fruit zones are the relative annual temperature and humidity. Broadly, there are three climatic fruit zones; the temparate zone, the semi tropical zone and the tropical zone. The first is marked by a long winter and in the second the winter is of short duration, and the tropical zone is marked by absence of frost. In the first zone the fruit trees shed their leaves completely in winter and in the second the fruit trees are almost ever green. In the tropical zone the fruit trees are ever green, and in a rather ever growing condition.

Soil:

It is generally known that there is a special adaptation of fruits to soil. Some flourish well in clay soils, others in open or sandy soils. If this fact is given the attention it deserves, the promiscuous and whole sale distribution of a few varieties all over the country would cease and the varieties best suited to a locality alone would begin to be cultivated. In selecting soils for profitable orcharding every care is to be taken that only the most suitable soils are chosen. For, a wrong selection of soil is always met with serious and irrepairable loss. Some fruits are more or less cosmopolitan in their nature and thrive in a wide range of soils but some are very exacting. It is for this reason that sometimes fruit trees can be made to grow in uncon-

genial soils by working them on stocks adapted to special conditions of soil and climate but this is a very special matter. The importance, therefore, of giving special attention to the subject of adaptability of species and varieties must be realised. Particular attention should also be given to the general character of the land. The condition of existing fruit plantations in any neighbourhood usually gives a fair indication of the soil conditions. It is always wise to seek the advice of an expert. Again the character of the surface soil alone is not a sure guide in selecting the soil; the character of the sub soil is equally important. Good agricultural land need not necessarily be good for fruit growing. The latter has to support a perennial crop and provide for the foraging capacity of deep rooted fruit trees. The physical condition of the orchard soil is often of greater importance for the successful growing of fruit crops than its chemical composition. It is relatively easy to improve the chemical composition of the surface soil than the physical condition or the sub-soil. Good orchard land is always associated with a deep and open sub soil. The adaptability of land for satisfactory tree growth is indicated by the character of the soil from the furface to about eight feet depth. The average farmer knows but little about the condition of the sub-soil, but he can and must get acquainted with it by digging pits 6-8 feet deep in different parts of his farm. The number of pits necessary to get a correct picture of the sub-soil will vary. If half a dozen pits scattered over, a ten acre plot, give about the same result in each case, it may safely be assumed that these show the general character of the sub-soil. If however, they vary, more pits have to be dug until the limits of the different formations are known.

An open porous sub-soil insures drainage and helps to promote the development of deep feeding roots. The water table should also be over six feet below the surface in any part of the year. It is important that the soil be of uniform texture, as variation in texture in the feeding zone results in marked differences in the moisture content, aeration and plant food supply, leading to irregular root formation and injury to a part of the root system.

Variation in soil texture also brings about un-even drainage conditions. Defective drainage and inadequate aeration cause serious harm to fruit plantations. Shallow soils are un-suitable for fruit. A poor but deep soil is better adapted for fruit growing than a richer but shallow soil with compact layers of rock, stones, kanker or gravel though superimposed by good soil. Under such conditions the root system is restricted to a few inches of the surface soil and the trees are subject to damage by high winds and premature death.

Chemical Composition of Soil:

Some fruit plants tolerate or even prefer a slightly acid medium while others may require slightly alkaline medium but most fruit trees require a neutral medium. An alkaline soil is disastrous for fruit trees and has been responsible for the immense losses to unwary growers. Alkaline soils disintegrate soil granules corrode the roots, making the absorption of water and the working of the soil difficult. The leaves turn white and the edges and tips get burnt. In acid soils also, the growth of trees is retarded. Therefore for ensuring success with fruits trees, it is best to have the soil as well as the irrigation water chemically analysed and the advice of a competent chemist sought before fixing upon a site for planting.

The Commercial Importance of Citrus Fruits:

Fruits of the citrus family are among the most widely grown fruits of the World. It is mainly a sub-tropical fruit, found growing in the tropical zone and also in some parts of the temperate zone. Among the most extensively grown sub-tropical fruits of the World, the citrus ranks next to grapes and olives with an acerage of about 20 lakhs of acres. In the United States, it is easily the leading commercial fruit, grown over an area of over 6 lakhs acres.

In India the Chief Citrus Growing Provinces are Andhra; Madhya Pradesh, Bombay, Coorg, Assam, Bihar, Mysore, East Punjab, Hyderabad, West Bengal and Uttar

Pradesh with a total acerage of 1,64,410 distributed as shown under:—

1.	Madhya Pradesh	38,738 Acs.
2.	Andhra	30,130 ,,
3.	Bombay	25,786 ,,
4.	Coorg	16,855 ,,
5.	Assam	15,000 ,,
6.	Bihar	12,766 ,,
7.	Mysore	5,170 ,,
8.	East Punjab	3,536 ,,
9.	Hyderabad	2,700 ,,
10.	West Bengal	1,742 ,,
11.	Uttar Pradesh	1,147 ,,

The origin and history of citrus fruit are not exactly known except for the fact that they are natives of South Asia. Some species had their native home in China and some in India. Chinese literature belonging to as earlp as 2200 B.C. appears to refer to the cultivation of some species of citrus fruits. It is possible that owing to Commercial intercourse between India and China in ancient times citrus species may have been carried from one country to the other and from other countries to these countries. The Citron (Turanj)—is generally considered as a native of India and also, the lemons and the rough lemon 'Jamburi'. The sweet oranges as their names — Malta — Mosambi (Mozambigue) indicate, must have come to India from the West. Loose skinner oranges—Santras now extensively grown in various parts of India sem to have come into prominence during the Mogul Period. Of the citrus species the loose skinned-Mandarins are the most important that are grown commercially in many parts of the country. Next in importance are the sweet orange, limes, Sour Oranges, sweet Limes, Pummelo and Grape-fruit. The chief centres of cultivation and the extent are shown below:

Tract.	Loose Skinned.	Sweet Orange.	Lime.	Sour Orange.	Sweet Lime.	Pummello.	Grape Fruit.
Madhya Pradesh	22,000	—	—	—	—	—	—
Assam	14,000	—	—	—	—	—	—
Coorg	10,000	—	—	—	—	—	—
Punjab	7,500	7,000	1,600	—	—	—	100
Madras	4,500	8,000	12,000	4,000	—	—	—
Sikkim	2,500	—	—	—	—	—	—
Hy'bad	4,793	5,723	—	—	—	—	—
Bengal	1,300	—	1,600	—	—	—	—
Bombay	—	11,000	3,000	—	—	—	—

Other Citrus varieties:—1,007

N.B.:—The figures under Hyderabad Pertains to 1950-51.

CITRUS VARIETIES

Citron:—Citrus Medica — Turanj (Madi Phalam):

This fruit commonly known as "Madiphalam" is used for medicinal purposes. It is a small tree 8′ to 10′ in height with straggling branches, fruit is oblong, ring soft, juice sacs slender, core yellow and seeds white when cut. It is grown mainly as stray trees in home compounds or in orchards with other fruit trees.

Lemon (Citrus Limon):

A small tree 10—20 feet high with short thorny branches. It is of recent introduction in South India. The tree yields heavy crops even from 3rd year. The fruit is used for the same purpose as acid lime or Kagazinimbu. Among the promising ones are seedless lemon. Napalee and Malta lemons.

Lime:—Citrus Aurantifolia: (Nimma) or Kagzinimbu:

This is commonly called acid lime (Nimma in Telugu). It is a small tender bushy tree with fine twigs and leaves, stiff and sharp thorns and producing large crops of acid fruits with thin rinds. The leaves are almost wingless or narrowly winged. The flowers are white and non-scented.

The juice sacs are slender and spindle shaped. The core is solid and the seeds are green when cut. This variety accounts practically for the entire commercial line production in South India. From a survey of some of the lime orchards, it has however, been observed that several other forms of limes also are found as stray trees in private orchards. One is a small, roundish oblate fruit with smooth and shiny rind and with inner partitions fairly visible from outside the skin. It has light mamilla and pale green flesh. Another form has similar fruits but with out mamilla. Yet another hybrid form bearing red fleshed pulp has been noted at Madanapalli. These novelties in the group of limes are yet to prove their superiority over kagzi lime.

Pummelo Shaddock Citrus Maxima — (Pampara Panasa in Telugu):—

It is mainly a home yard fruit rather than an orchard fruit. As stray trees, it is found all over South India excepting in elevations exceeding 5,000′ above M.S.L.

Pummeloes are distinguished from grape fruit mainly by the more broadly winged petioles, larger fruit size thicker rinds, in having a tough and more solid pulp, monoembryonic seeds and in bearing fruits mainly as singles.

In the past the pummeloes were raised by seed and hence they exhibit large variations. They are broadly grouped either according to shape which consists of (1) Oblate or globose fruits flattened or Neckless, (2) elongate or pear shape fruits with neck; or according to colour of the flesh white or Pink.

Grape—Fruit: Citrus Paradisi:

Fruits are large, pulp light green, juicy, juice sacks fairly large and coherent, patioles rather broadly winged. Pulp adherent to peel, seeds white, smooth and poly embryonic. Though a fruit of great economic importance in some parts of the world, the grape fruit has yet made no appeal to the South India palate.

It may offer great possibilities as a source of healthful and refreshing bottled beaverage.

Sour Orange:—(Citrus Aurantium):

Sometimes, these are also called as Seville or Bigarade Oranges. They all resemble the sweet orange in general appearance of the fruit and tree but are distinguished from the latter by the acidity of the pulp, hollow core of the fruits, winged leaf petioles and by characteristic odor of the crushed leaves and fruit rind. The fruits are medium sized, peel rough and scarlet orange. Pulp is very sour or bitterish. Flowers are sweet scented. Fruit core is hollow and filled with strings of fibre. Seeds are green when cut.

Unlike the sweet oranges. These are reputed to be resistant to gum diseases. Due to this and other reasons; it has become popular as a root stock for sweet orange in many parts of the world.

Sweet Orange. (Citrus Sin-ensis):—

The fruits are medium sized, peel orange coloured, pulp sweet, petioles narrowly winged, pulp adhering to the peel, seeds poly embryonic. This is the msot popular Citrus fruit. Fruit is edible as fresh fruit and in the form of Juice. They are usually divided into 3 groups (i) Those that predominantly bear normal fruits, (ii) those yielding very large fruits with navals opposite the stalk end and (iii) those with red or redstreaked flesh. In South India; the first group is of great commercial importance. Sat Gudi or Chinese orange and Batavian of Andhra and Mosambi or Muzambique orange of Hyderabad come under this class. Mosambi of Hyderabad differs from the above 2 varieties in having prominent streaks on the rind and a circular goove at the Stigma end, the former of which gives it a rough exterior. It is also more difficult to peal and contains more seeds. Though sweet; it is almost insipid, owing to lack of flavour and an inadequate blending of acidity with sugars.

Mandarin Orange: (Citrus Reticulata):—

These are also called Tangerine or Loose skinned oranges. The peel of the fruit adheres to the pulp loosely. The juice is usually sweet. Flowers are usually perfect, petioles with narrow or broad wings. Seeds are small and embryo is green. The names Mandarin and Tangerine are often used interchangeably, but the latter name is more generally applied now to varieties which produce fruits of deep orange or Scarlet rind colour. Being cheaper than sweet orange and having sweeter taste peculiar to itself; the loose skinned orange has a wide appeal to the public as a desert fruit.

Sweet Lime:—(Citrus Limettoides) (Telugu — Tiyya Nimma):—

A fairly large spreading tree; leaves about the size of the Sweet Orange but slightly light green in colour; flowers large and pure white, fruit globose, smooth; glossy; juice insipid or mildly sweet with no flavour. It is grown on a very small scale in some parts of India because it is hardy and ripens late in the rains when usually no other citrus fruits are available.

Citrus Relatives:

There are any number of plants closely skin to the edible citrus and growing in many parts of the world which appear to have great potentialities in the future development of the citrus as well as other industries. Some with sweet scented flowers may become valuable in the perfume industry; some may be found well adopted for hedges; some for crossing for new varieties, others are bound to have value as stock plant for cultivated citrus fruits to widen the range of soil or climatic adoptability. Home gives a list of over twenty such plants of which some are quite familiar to Indian Horticulture and some are even indigenous.

Examples:

1. Trifoliate Orange.
2. Wampee.

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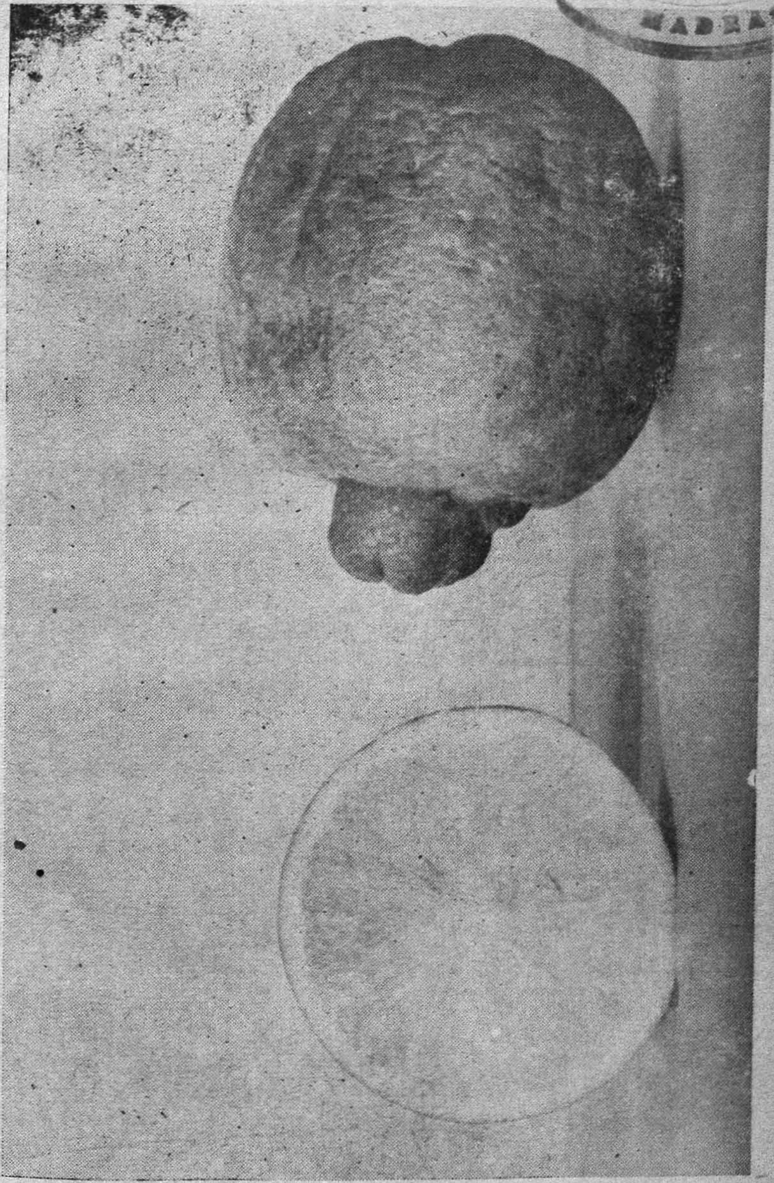

Santra (Mandarin Orange)

3. Orange Jessamine.
4. Wood Apple.
5. Feroniella Lucida (Telugu — Machipathri or Bilvam).

POPULAR CLASSIFICATION OF CITRUS SPECIES GROWS IN INDIA.

1. Sweet Oranges: Tight Skinned Oranges: Varieties:— Mosambi — Sathgudi or Chinese, Batavian (Batai) Malta, Malta Blood, Jaffa Washington naval, Valencia late, Pure apple Ruby, and St. Michael.

2. Mandarin Orange — Loose Skinned Oranges: Varities:—Santra, Narangi, Coorg, Syelet, Sikkim, Kamala or Kaiwala, Beauty and Cleopetra, Lada Reshmi.

3. Sour Orange: Varieties:—Karna, Khalta, Kitchile.

4. Lime: Varieties:—Kagzí, Pattemby, Suatembu.

5. Lemmon: Sour Lemon. Varities:—Eureka, Lisbon, Villa France, Geneva Jamburi.

6. Pummelo—Shaddock: Varieties:—Chakotra, White, Pink, Mammoth, Pear shapped, Round.

7. Grape Fruit, Pomelo: Varieties:—Marsh, Seedless, Trumpa, Duncan, Fosters seedling, Mecorty.

8. Citron: Citron — (Turanj).

DISCRIPTION AND DISTRIBUTION OF THE COMMERCIAL OF CITRUS FRUIT OF INDIA.

1. **Mosambi:**—Round or slightly oblong, colour greenish-yellow to yellow, rind leathery, thin or thick creased, smooth or rough, flesh whitish yellow, acidity low, have a circular mark on the apex. Crown in the Deccan, Bombay and Madhya Pradesh.

2. **Sathgudi or Chini:**—Crown mostly in South India and Andhra. Fruit slightly oblong, colour greenish yellow rind thin or thick, leathery, juicy, sweet.

3. **Batavian-Orange:**—Crown in Andhra.

4. **Washington-navel:**—Grown on a small scale. Fruit slightly oblong. Large; rind slightly thick, leathery, with an umbelical depression, or a protuberance at the apex; juicy, sweet and seedless.

5. **Maltas:** Grown largely in Punjab. Fruit oblong, skin leathery Pitted, slightly thick, colour orange red, juice plentiful, acidity and sweetness well blended.

6. **Malta Blood:** Like the malta in form but slightly smaller in size, colour deep orange red, flesh orange coloured with red streaks, very Juicy, Sweet Acidity and sweetness well blended.

7. **Santra:** The most important commercial variety known popularly as the Nagpuri Grown round about Nagpur, Hyderabad and Bombay. Fruit oblate flattened, some time broad at the base and tapering at the apex, Apex flat or nippled, base—depressed, Rind thin, smooth, colour greenish or orange, sections easily separated, pulp Juicy, flesh light Orange.

8. **Coorg-Orange:** Similar to Nagpuri Colour orange yellow, or greenish yellow.

9. **Sikkim:** Fruits have a brilliant red colour.

10. **Sour Orange:** Mostly grown in Madras Fruit irregular in shape, colour green, rind thick, pulp white, very sour.

11. **Lime:** Kagzi is the most widely grown variety throughout India. Fruit round or oval, colour yellow rinned thin, shiny and smooth, pulp whitish, juicy, flavour distinct.

12. **Lemons:** Fruit oblong, colour lemon yellow, apex nippled, base tapered slightly, rinned smooth flesh greenish yellow, juice abundant, sour.

13. **Sweet Lime:** Fruit globose, rinned smooth, shiny, colour Lemon yellow, flesh whitish, sweet.

14. **Pummelo:** Largest of all the citrus fruits. Being slightly bitter in taste, it is not very popular. The Davenhalli pommelo of Mysore is reputed to be a good fruit. Fruits oblate or pyri form, large, base depressed, rind revy thick with a thick lining of pith, oil glands large, flesh white or red, juice sacs large, easily separated, bitter, slightly sweet and acid.

15. **Grape Fruit:** Not largely grown except in Punjab Not very popular in other parts. The most popular among the varieties introduced in India is the Marsh seedless. Fruits oblate rounded, colour light yellow, rind thick, smooth, juice sacs small, and leathery not pronounced as in pummelo. Sweetness and acidity well blended.

16. **Citron:** Not of much commercial importance used for medicinal purposes. Fruit oblong, large in size, rind warty, colour lemon yellow thickly pulp sour, flesh white, juice scanty.

Propagation of Citrus Trees:

Citrus trees may be propagated sexually by the sowing of seed or vegetatively by cuttings, layering, air layering or Gootee, budding, grafting and top working. Until very recent times propagation by seed was very common, but gradually it is giving place to vegetative methods especially layering with certain kinds and budding with all the commercial varieties. While not many years ago the planting of seedling trees was rule in several parts of India, now it is becoming an exception. The beginning of any fruit industry is naturally marked by the planting of trees grown from seed. Vegetatively propagated plants represent adaption to new conditions, specialization and progress. However, propagation by seed has got its own advantages and should therefore not be discountenanced entirely. Plants grown from seed are vigorous, long lived and tend to increase the vitality of the specier, and often give rise to new varieties. The art of

propagating plants by other methods is based on long experience and its successful application has been the means of raising stocks quickly which otherwise would have been possible. Many plants do not succeed unless they are grafted on to another kind and some varieties even fail to produce valuable seed. In such cases propagation by vegetative methods comes to the rescue. Seedling plants take a long time to come to bearing. Vegetatively reproduced plants are capable of of blooming much earlier, some-times within a season or two. Also, it is the only easy method by which the characteristics of the parent plant are perpetuated; those characteristics which cultivators are most interested in, such as color, size form, flavour etc. These are not reproduced in seedlings especially of those plants which have been modified by Cultivation. There are other advantages also. Besides starting to bear at an earlier age it is possible to secure fruits of uniform size and quality. Varieties ripening at different seasons may be planted to obtain a continual crop. The grower has a choice of stocks by which he can hope to obtain better results. In addition, it is possible to avoid diseases by the use of resistant stocks. Constant propagation by vegetative methods, however, has been found to tend towards a gradual deterioration of the species.

Citrus seeds used for Propagation:

There is a great deal of difference in the form and size of the kinds of citrus seeds that are commonly used for the growing of stock. It is helpful for the fruit grower to acquaint himself with them lest he should be misled by nursery men.

Propagation by seed:

The production of well developed, vigorous growing stock is of the utmost importance and very careful attention must therefore be given to the selection of seeds of good quality and vigour. If seed is wanted for plantation purposes there must be rigorous selection in the choice of the parent plant and the fruits from which seeds are to be taken. It is always a great advantage to choose trees that

are strong and healthy, resistant to desease, bear good crops every year and yield fruits of uniform and acceptable quality with regard to size, shape, juiciness, flavour, taste etc. Almost all citrus species are poly-embryonic and produce seedlings which are capable of growing into healthy trees closely or wholly skin to the parent plant and yield fruits of high and uniform quality if care is taken to select the seem properly. For the successful propagation of plants by seed it is also essential that they should be sown in the proper season and in the right manner.

Vegetative Propagation of Citrus Trees:

Several methods of propagating citrus trees by vegetative methods are practiced in different countries and in different parts of India. Experience, however, shows that of all these methods, propagation by budding (shield budding)—has proved to be the most successful for both large scale nursevy practice as well as orchard performance. This is associated with the raising of seedling of suitable root stock varieties. The most important varieties that are in use of the citrus industry are:—

1. **The Sour Orange (Citrus Aurantium):**

This is one of the most hardy varieties of citrus that is extensively used as stock for most of the commercial varieties in most western countries. According to Hume it is responsible for the production of over twenty five per cent of the world's output of citrus fruits. It is resistant to the attacks of foot-rot and gum diseases. In America it is said to be a failure as a stock for the Kumquat, Lime and Satsuma Orange. Hume thinks that under favourable conditions of climate and soils for its best growth and compatibility this will be a very satisfactory stock to use.

2. **Sweet Orange (Citrus Sinensis):**

This is not a deep rooted plant and therefore useful only on light soils. It is subject to foot-rot disease and cannot be used on damp soils. Under congenial conditions however trees budded on this stock grow rapidly and develop into shapely trees.

3. **Sour Lime (Citrus Aurantifolia):**

While according to Brown it is a suitable stock for its own scion, it is usually found to be difficult to work upon. It is therefore not used on a large scale for the commercial varieties. In recent years it is said to have given encouraging results when used as root stock for lime and sweet orange at Kodur.

4. **Mandarin Orange (Citrus Nobilis Var Deliciosa):**

It is said to be immune to scale and resisted to gum diseases but is not much favoured in India. It is used in China and a variety called Cleopatra is used in America.

5. **Rough Lemon (Citrus Lemonia) Jamburi:**

According to Hume this variety is the most susceptible of all the stocks commonly used for citrus in western countries to damage by cold, and cannot be expected to increase the hardiness of the variety worked on it. It has a well developed tap root and the crown roots which spread to a considerable distance from the trunks and lie close to the surface. This and its capability of inducing a rapid growth in the scions worked on it, makes it a valueable root stock for dry soils or on those containing insufficient plant fond or where the plant food is not readily available because of adverse soil conditions. To some extent it influences the shape and growth of the variety worked on it. The first crops produced on trees with this stock are thick skinned, wanting in juiciness and of inferior quality. This is probably due to rapid growth. Usually vigorous growth and high quality fruit do not go together when, however, the trees have passed the period of rapid vegetative development these defects disappear. For limes and lemons this variety has been found to do well as stock producing fruit of high quality and so also for pomeloes and tangerines. It is resistant to foot rot, but as it is subject to gum diseases it is considered not satisfactory for lemons in California.

In India the rough lemon known commonly as Jamburi is almost universally recognised as the best root stock

for the raising of commercial variety of citrus—santra, mosambi and sour lime. While it is of little economic importance by itself, it forms the foundation of the citrus industry in almost all the chief citrus growing areas of India. It has all the qualities desirable for a stock plant. According to Paranjpye the qualities required are:—

1. It must remain in good sap flowing conditions for a considerable time to enable the budding operation to be done at any suitable time.

2. It must grow fast.

3. The bark on being loosened from the wood below must separate easily.

4. The bark must not tear irregularly.

5. It must feel watery to the touch inside.

He also points out the defects of the other root stock varieties tried in Bombay. The 'Mahalung' Citron he says is some what brittle and less mucilagenous and the sap flowing condition lasts only for a short time; the Reshmi Orange is not at all suited as a stock, for, the bark closely adheres to the wood below and it is not moist enough inside. This and the Nagpur Orange stock when cut off above, the wood often turn black near the cut end causing ultimate decay. With the Pummelo (Shaddock) as the stock the great difficult is that it does not stand well the trimming of its top root and hence it is not well suited as stock plant which has to stand repeated transplantings. The Mosambi stock is very sensetive to col (as in case of low temperatures) and the part of the bark of the stem that remains under water decays in a very short time. The Jamburi stock is free from all these faults.

Experimenters at Kodur (Andhra) have observed that in addition to the merits mentioned above the Jamburi has the following qualities:—

1. It has a very high percentage of germination.

2. It produces more seedlings than any other root stock variety and also very high proportion of vigorous variants ready for being worked upon within a year's growth.

3. It gives a very high percentage of successful 'take,' of Sathgudi and acid limescions.

4. Seedlings transplant well and make a good stand in nursery beds.

5. Their root system is well developed.

6. The scions worked on it grow vigorously during the pre-orchard life.

The accumulated experience of experimenters all over the World, give the following indications:

1. Trees worked on sweet orange stock do not thrive well on light soils and do not withstand drought.

2. Sour orange root stock does not do well on light soils, but yields satisfactorily on heavy soils.

3. In the orange growing tract of India the Jamburi is referred as a stock for the tight skinned oranges and the sweet lime root stock for the loose jacketed varieties.

4. For sweet orange, California prefers the sour orange root stock, Japan the citrus Sunki, Flovida the sweet orange, Palestine the seed lime or lemon, and some very cold regions the trifoliate orange.

Experience in Andhra:

1. Sathgudi scions worked on acid lime (Gajanimma) and Jamburi grow very vigorously and attain

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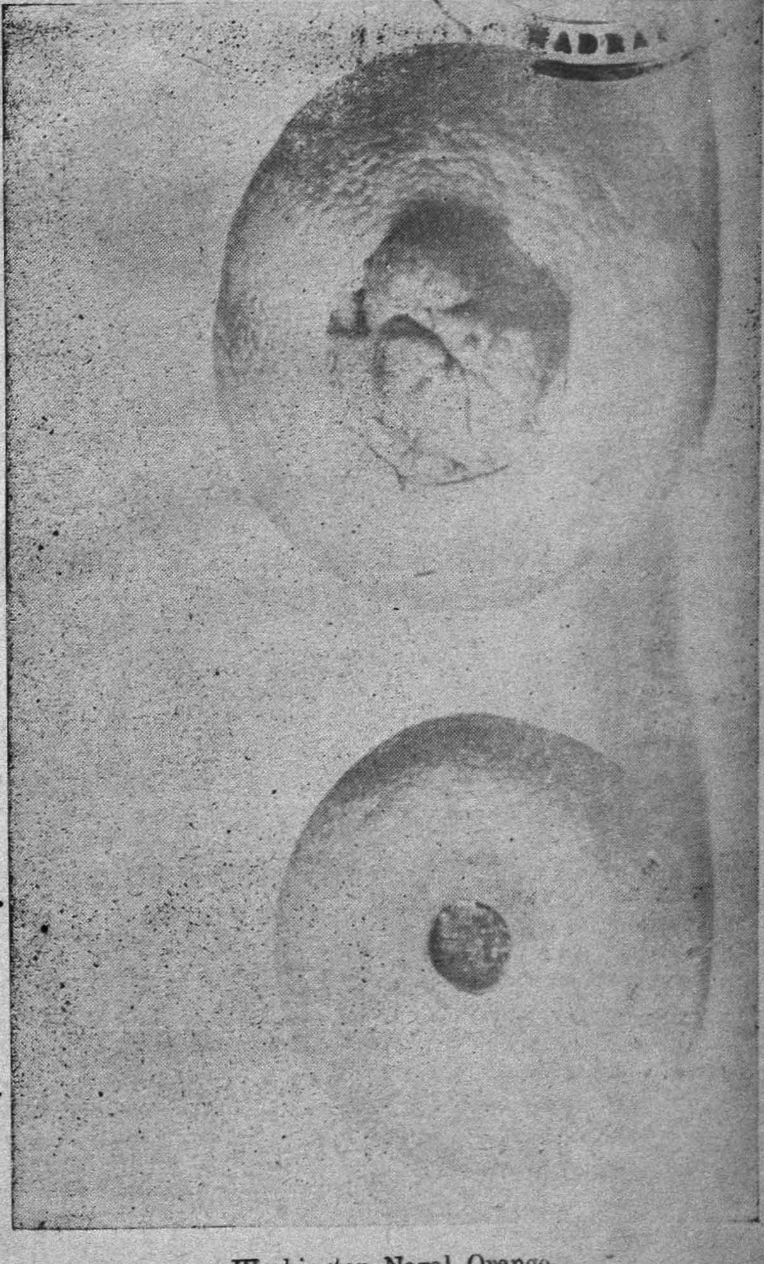

Washington Naval Orange

good tree size while wood apple and loose skinned stock produced poor sized trees.

2. Sathgudi on Sathgudi was found very compatiable giving smooth bud union but failed to give the same results when worked on the wood apple, sour orange and the pummelo.

3. Sathgudi on wood apple stock produced crops long before the seedling trees came into the bearing stage.

4. Trees on Gajanimma are very susceptible to gum disease and to root-rot especially in years of heavy rainfall.

5. Acid lime on rough lemon produce the largest stem size and budded trees larger tree-size than the seedings.

6. Acid lime seedlings on acid lime stock are resistant to die back and wither-tip diseases, while the same on Gajanimma root stock are very susceptible to these diseases.

7. In Punjab, the Karana Khatha has been found useful for all commercial varieties except Malta Blood for which rough lemon proved a better stock. It produces very vigorous trees. Sweet lime has a dwarfing effect.

8. Halma reports that Eureka lemons on their own roots after a certain number of years tend to deteriorate in vigour, hardiness and production.

9. According to Hodgson and Cameron in citrus trees the scion determines the rate of growth and ultimate size of the tree when it is weaker than the root stock.

10. Experience in Bombay shows that seelings of different strains of Jamburi varied considerably in

their general performance and vigour of growth under normal conditions.

No problem in Citrus cultivation is more worthy of careful investigation from all angles than that which relates to the root stocks, their adaptibility to soil and Scion; their resistence to disease, and their influence on crop production. The work of discovering the right type of root stock for successful cultivation of citrus varieties grown under different climate and soil conditions is of primary importance in the interests of the expansion of the citrus industry in India.

The Production of root stock plants:

The production of well developed vigorous growing stocks is of great importance, for, on it largely depends the success or failure of the plantation. Therefore great attention must be given to the quality and vigour of all seeds used. They should be procured from fully matured fruits taken from strong-growing healthy trees and after being extracted from the fruit. All immature or poorly developed seed should be rigidly discarded. From observation made by propagators of citrus plants, it may be estimated roughly that the following varieties contain usually the number of seeds shown against each:—

1.	Sour Orange	20	Seeds
2.	Pomelo	55	,,
3.	Sweet Orange	18	,,
4.	Rough Lemon	20	,,
5.	Trifoliate Orange	25	,,
6.	Sathgudi	20	,,
7.	Gajanimma	40	,,
8.	Kichli	20	,,
9.	Loose Skinned Orange ...	10	,,
10.	Acid Lime	8-10	,,

In estimating the number of seeds required for a required number of seedlings it is better to plant twice as many seeds as the number of stock plants required. To promote selection of only the best and most vigorous seed-

lings this number should necessarily be increased. If at least two times the number of seeds required for stock are planted it will make it possible to grade out the finest seedlings and thus greatly enhance the quality of the nursery trees grown.

For a Jamburi root stock seedling plantation on one acre the number of fruits required may be calculated as follows:—

One fruit has been estimated to contain 20 seeds and since being polyembryonic in its nature, one fruit may be expected to give at least 30 seedlings. Planted finally in the nursery at, say, a distance of 2′ by 1′ an acre, will take about 21780 plants. At 30 seedlings from one fruit the total number of fruits required will be 726. The cost at about rupee one per 100 will be Rs. 7/4-. After necessary weeding out of all undesirable seedlings one acre may be able to produce about 10,000 seedlings of the desired quality.

It has been found that there are a number of types of the Jamburi (Jamberi) in different parts of India. The type that is in common use for root stock, has fruit which are globose in shape with a slightly loose wrinkled rind. The trees are found to bear almost throughout the year the chief season in Deccan and Bombay being July — August and in North and South India October to January.

Extraction of Seed:

The seed may be separated in two ways,: (1) by cutting the tree-ripe fruits taken from sound and healthy parents in halves and squeezing them out into a sieve to allow the juice to run through the seed is then collected and washed free from the pulp; (2) by allowing it to rot after which the seeds are separated from the rotten mass by washing, preferably in running water. All seeds are not uniformly good. Some are large, some small, some heavy and some light. To remove the undesirables, it is a common practice with careful propagators, to drop the seeds in a basin of water. Seeds that float on the top and

remain in suspension under the surface are unfit for propagation and therefore thrown away. Those that readily sink to the bottom are collected for use. It is common experience that citrus seeds of whatever kind or variety lose their viability in a short time. If allowed to become too dry the cotyledons separate and they do not germinate. Therefore it is advantageous to sow the seeds fresh after drying them for a day or two. With careful storing, however, seeds continue to maintain their viability for a reasonable time. Jamburi seeds like the seed of most other varieties are polyembryonic. A single seed is capable of producing three or four seedlings, sometimes more. Which however are not all of the same vigour. It is therefore necessary to select only the large sized seedlings arising from a polyembryonic seed.

Some times the -fruit contains seeds with split-coats. They make healthy seedlings. In overripe fruit these germinate inside the fruit.

Seed bed and sowing:

Selected and properly graded seeds are sown in raised seed beds which are usually 2½′ to 3′ wide and 10—12′ long. To prepare the bed the selected site which should prefrably be in the high lying part of the garden, is dug upto a depth of about nine inches. The clods are pulverised and well decomposed manure is added at the rate of about one basket per running yard length of the bed. The manure is then thoroughly mixed with the soil and the bed built up to rise about 6″ higher than the surrounding ground and levelled. This ensures proper drainage. Commercial fertilizers, if used, should be applied to the bed two or three weeks before the seed is sown. It is. unsafe to apply fertilizers and sow seeds immediately. The seed should be sown at a depth of about three fourths of an inch, not very thickly, in lines across the bed, the intervening distance between two adjacent lines being about three inches. The soil should be slightly moist at sowing time to secure the best results. After sowing it is useful to sprinkle a thin layer of sand over the seed bed

to prevent the seeds from getting washed out. Watering during the early months should be done with a watering. Can fitted with a fine rose. Only the upper layer of the bed should be kept moist till germination occurs in about 20 days. As 'damping-off' a fungus disease some times causes trouble when the seedlings are young, the seed bed should be watched carefully for its appearance. To prevent its appearance the upper layer of soil in the bed should be kept dry and the lower layer moist. If, however, the disease shows up the bed may be sprayed with bordeaux mixture or any other copper fungicide fungicopper, copper sandoz, or perinox etc. Prompt attention will usually prevent serious damage. A sharp lookout for insects especially the caterpillars of the lemon butterfly which look like the dropping of birds when very young should be kept. and if they appear, they should be hand picked. The young seedlings should be thoroughly sprayed at frequent intervals. When the seedlings have grown for about a month, the beds should be carefully weeded and the space between the lines of seedlings lightly stirred with the help of a Khurpi. When the seedlings are about two months old it is time to thin out the seedlings removing all the weaker ones and all but the best of the seedlings arising from a single seed. This operation helps to relieve congestion and affords room for the remaining seedlings to develop properly. When the seedlings are three to four months old in the seed bed they should be removed carefully and transplanted in suitable nursery beds; flat beds or ridges and furrows. In the former the seedlings are placed in double rows about a foot apart and separated from the adjoining double row by about two feet. In the ridge and furrow method the plants are set one foot apart on one side of ridge which is separated from the next ridge by two feet. In some places four rows are planted alternatively in a single bed. The object of all the systems is to have the plants at distances conducive to good but straight growth without much branching and to provide facility for the operation of budding to be done without much inconvenience. In addition to this initial precaution the side shoots have to be removed about once in every

two months to gain the same object. A straight and erect stem is essential for budding upon.

Care of the Seedling Stock in the Nursery:

Immediately after transplanting the seedlings lifted from the seed bed, the nursery beds are watered, and again after 4 days and afterwards at regular chosen intervals which is determined by the soil conditions. Generally irrigation once a week is considered sufficient. In the rains irrigations are given at very much less frequent intervals. To help the young seedlings to grow vigorously the plots are kept clean of weeds, the soil is stirred frequently to provide areation, light doses of ammonium sulphate, and oil cake are applied at regular intervals. Treated in the above manner the seedlings become ready for budding in about a year from the time of transplanting. Rigid selection of only the best seed and a rigorous weeding out of all weaker seedlings gives first class stock ready for budding in about a year from the sowing of seed. As the root stock forms the foundation of the future tree it is essential that only the best are selected for propagation.

Selection of Bud Wood and Scions:

Both bud wood and scion should be selected from well matured wood of not more than one season's growth. But wood which is round and marked with whitish streaks along a green back ground and containing thornless, plump buds are the best for budding work. Such wood should be selected from healthy trees of known origin and of proved outstanding quality. In view of the great variations in production among the trees in citrus plantations, the need for a careful selection of parent plants for propagation work cannot be over emphasized. Only parents of high quality are capable of transmitting high yield to their progenies. Thorny wood should be avoided whenever it is possible to do so. In cases where the variety desired to be propagated is particularly valuable almost any bud, small, immature or already growing may be made to grow. Such buds may be taken from immature wood which are usually more or less angular. Some propagators are

said to be of the opinion that trees propagated by buds from old bearing trees come into bearing at a younger age than when buds are taken from younger tree of the same variety during the prebearing age. Hume, however, says 'it may be safely stated that when the bearing function has once become established it is carried from one bud generation to another regardless of the age of the tree from which the buds are taken'. After cutting the bud stick, the leaves should be removed and the wood cut into lengths of about a foot for convenient handling while budding.

Time of Budding:

With careful management budding may be successfully attempted during any part of the year. But generally it is better to avoid extremes of wet weather or temperatures. Heavy precipitation immediately following budding, excessive heat and severe cold are least conducive to success with budding.

Methods of Budding:

Budding is usually done when the stock is between one and two years of age, but there is really no age limit beyond which buds cannot be inserted by some method provided the stocks are of suitable size and the bark will slip easily. It is a common practice which has proved generally very convenient also to bud the root stocks at a height of six to nine inches. However a knowledge of the conditions under which the propagated plant has to grow should determine the point at which it is best to bud. In very cold regions the budded point is most subject to the effect of cold. In such cases budding as near to the crown roots as possible is convenient as it enables the budded position to be protected by banking earth around it. On the other hand such low budding exposes the trunk of certain varieties of citrus to the attack of foot root disease. For such varieties it is necessary that budding should be done well above the ground. Likewise to prevent gummosis the point of union of stock and scion should be beyond the reach of irrigation water round the trunks.

The most common method of budding and the one used entirely in-nursery work in almost all countries is what is known as the shield or the 'T'. Budding. In careful nursery practice, it is advantageous to have the stock plants prepared for budding some time in advance by removing all thorns branches and leaves below, upto and slightly above the point where the bud is intended to be inserted. This saves considerable time while budding. Before budding it is convenient to select the point of budding and to remove all thorns or branches that are likely to interfere with the work at that point. The actual budding operation consists in (1) making a perpendicular slit about an inch and a half in length on the side of the stock, and at its upper or lower and a cross cut with the aid of a budding knife. (2) Then the corners formed by the incision are carefully lifted and the bark eased out on either side of the perpendicular cut to enable the bud to be inserted easily. (3) The bud is removed from the wood in different ways in different localities:—

(a) Two perpendicular cuts are taken on either side of the selected bud and cross cuts taken at the upper and lower end. The bud is then eased out by working the point of the blade or a special contrivance provided in the budding knife and removed from the bud stick. To enable easy insertion into the 'T' Slit made, a stub of the leaf petiole below the bud is convenient. In the upright 'T', the bud piece is made to be pointed below and in the inverted the pointed and is above the bud.

(b) A piece of bark with the bud lying on the centre is carefully removed from the stock by working the knife from about half an inch below the bud, passing straight smoothly along and beneath it and finishing the cut about half an inch above the bud.

(4) The bud immediately after removal is held lightly between the thumb and the fore finger and with

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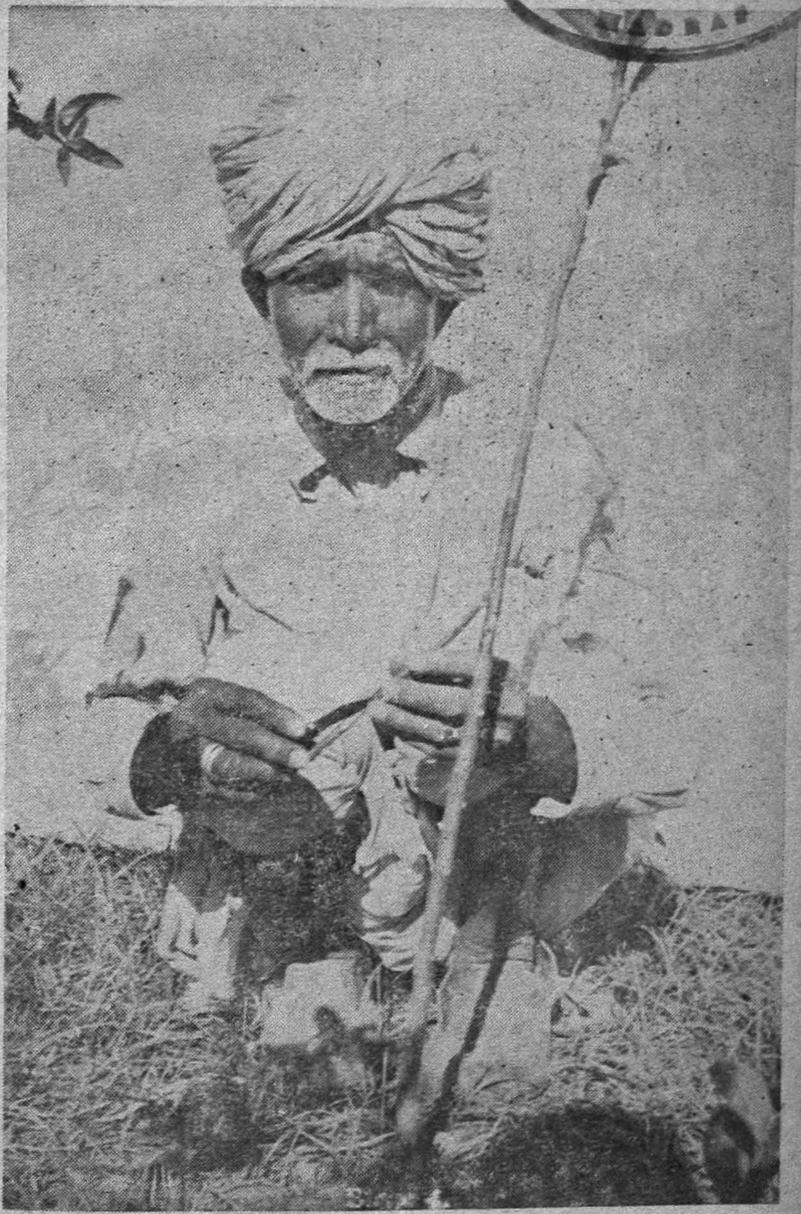

Stage. I.

Janburi Seedling (Pencil thick Size for Budding)

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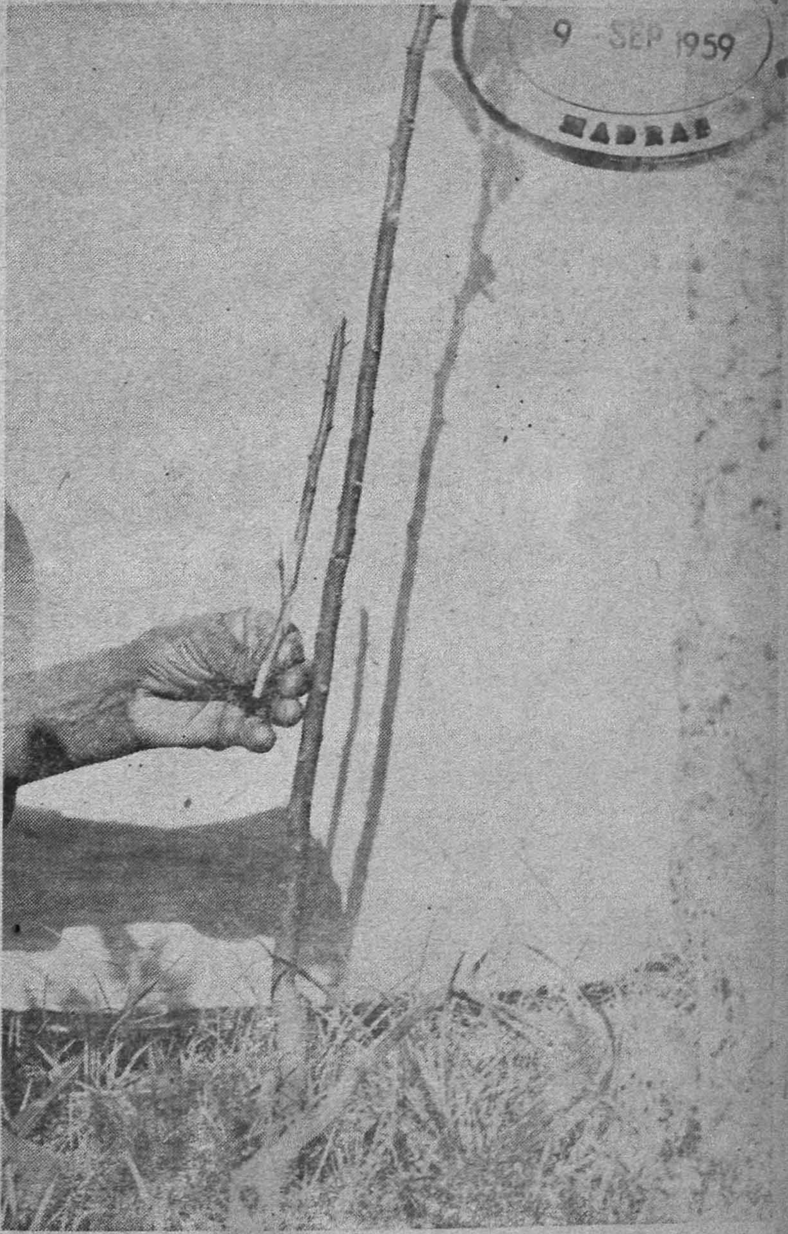

Stage No. 2.

Scion Budstick of Superior Variety for insertion.

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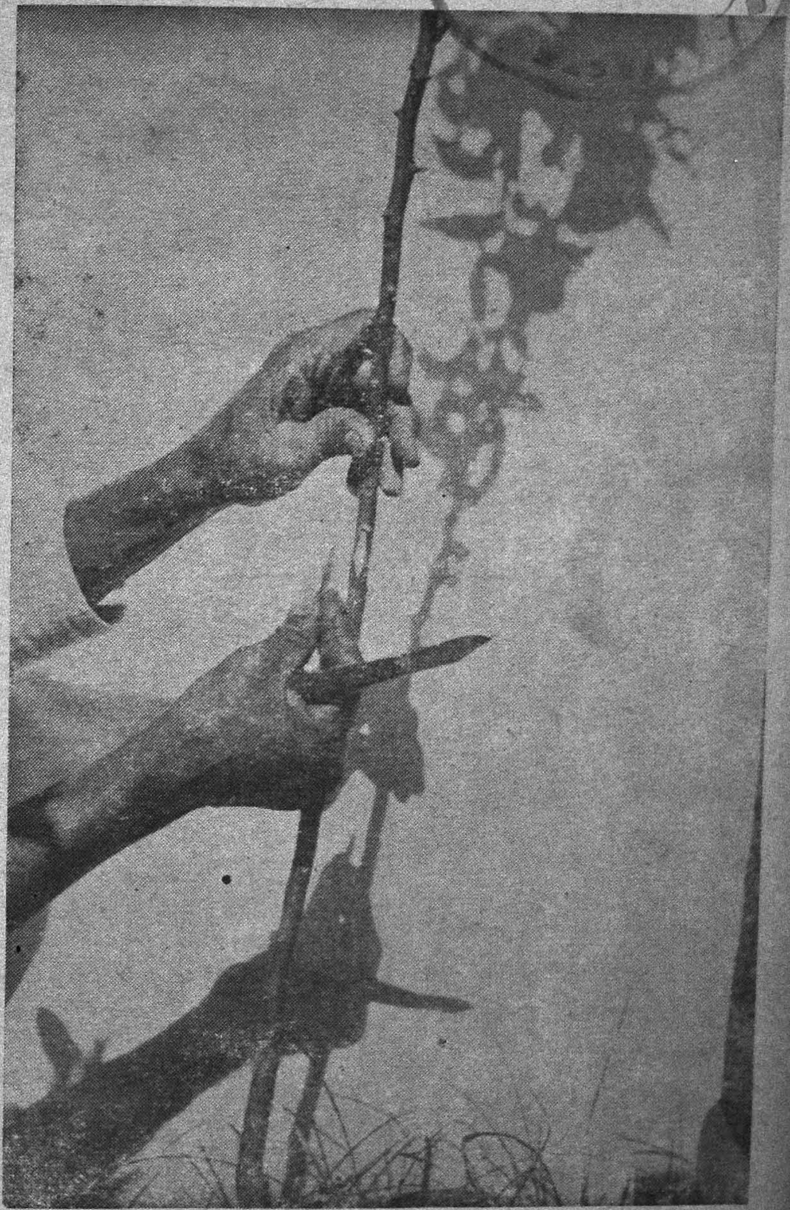

Stage 4.

Shield Bud to be inserted beneath Bark.

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Stage 5.

Bandage with Plastik film over Bud Joint after insertion of Bud.

the help of the leafstalk and shoved downwards in the case of the upright 'T' budding and upwards in that of the inverted 'T' in the inscision made for its reception.

(5) The bud should not be inverted in inserting. The leaf stalk or the scar left when it has dropped should be nearest the ground. The growing point of the bud should face upwards.

(6) The bud should be inserted on the northern side of the root stock to protect it from the direct rays of the sum. Some careful propagators take the additional precaution of covering the budded portion by means of a leaf or some other suitable material.

(7) After the bud is inserted the stock is wrapped by means of a strip of waxed cloth, plantain fibre (sopat) or raffia. Care being taken to keep the growing point of the bud open. The bandage is usually drawn over the intersecting cuts first and then worked upwards or down wards according as it is the inverted 'T' or the 'T' method.

(8) Expert budders with a correct knowledge of the optimium condition required for budding dispense with the cross cut. Only the vertical cut is taken and the stock bent a little towards the operator so as to make the **bark** open out naturally and **permit** the insertion of the bud. This is very useful as the **bark** of the rootstock stem when released holds the inserted bud tightly and in the desired position.

(9) In some parts of India especially in Kodur (Andhra) and many parts of the world the practice is to use bud shields with a piece of wood attached to it. It is claimed that this method gives greater success in budding and promotes a better growth of the bud sprouts.

Some times it is difficult to secure any thing except angled bud wood. In such case Hume recommends the following method:—

"The bud should be cut from the side removing a shield shaped piece of bark as in the other method, but with the bud at one side of it instead of in the centre. Then a right-angled incision is made with the lower cut either to the right or left to suit the bud. The angle of the bark at the intersection of the cuts is then lifted and the bud inserted. So as to have the bud in position in the up-right incision." This method should, he suggests, be called Shield Budding with a right angled incision. About two weeks after the operation the buds should be examined. If the buds are still green and a greenish line of new tissue shows around the edges of the incisions it may be taken that union has taken place. The bandage can be removed now and the stem of the stock above the bud point lopped, pruned back or removed entirely. Some propagators do this immediately after the bandaging is done. Lopping has been found to be not always necessary particularly with small stock. It is however considered safe to lop with stock of larger size. Lopping consists in cutting the stem of the stock on the side containing the bud about two inches above the bud and to about two third through it. The top is then bent over and made to fall along one side of the stock. These are removed entirely when the buds have made a growth of a foot or more.

Care in the Nursery:

It is a good nursery practice to stake the buds and keep the growing shoot tied to it every six inches or so to keep the young tree top straight. From time to time care should be taken to remove all sprouts that develop on the stock. When the young shoots have attained the desired height they should be topped and the side branches allowed to develop. While applications of manure to promote growth is necessary, too much of manuring to force undue growth is rather un-wise. In citrus plants, bud insertions very often give rise to more than one sprout of which one or two are strong and others weaker. A first class plant should have only one shoot growing from the bud in order to have a clean stem. A clean stem is desirable because at the bud joint it makes the union strong and

helps the plant to grow straight. It facilitates treatment of the joint against **Gummousis** by preventing inconvenient angles. A straight clear trunk about three feet high makes cultural operation easy.

Budding Old Stocks:

If for any reason it is intended to bud an old stock, the ordinary method will not be found practicable. The bark may break or crack during insertion as usually it is in such. stocks thick and brittle. Hume, under such conditions recommends a method which he names as shield budding with a curved incision. Angular buds should be chosen and removed from the wood with the bud placed at the right or left of the shield instead of being in the Centre. A curved incision is made in the stock to right or left to suit the bud. The bark is carefully lifted and the bud inserted and tied.

Top Working:

The need for top working very often arises when established seedling varieties like the Narangi, or Sour Orange or Karna become un-profitable in a competative market, or it is desired to reduce the number of existing varieties or certain diseases have got to be controlled, or when, as is often found, the root stock trees owing to the lack of knowledge of the grower, out grows and kills the scion and succeeds in growing to maturity without being detected. In all such cases new tops of desirable varieties could be provided and the trees put to better use without the necessity of going in for new plantations. It is frequently seen that established groves of inferior varieties are completely removed by growers due merely to ignorance. Obviously it is much more easier to top work young trees than old ones. In young plantations it is not advisable to top work until the trees get well established and develop a good root system. Young trees between the ages of three and seven year easily lend themselves for this method to be worked satisfactorily. It is possible to bud selected branches directly, after giving the trees the necessary pruning to enable buds to be inserted conveniently.

Two to three buds may be inserted on every branches that can be worked upon only taking care to bud as close towards the trunk as possible. The budding points on the branches may be about two inches thick. All branches that are not budded should be pruned out. The treated branches should have a few twigs at the extreme top and the intermediate branches if any should be cut away. After the buds take, only one of the strongest of the two or three inserted should be allowed to grow and the others removed. And when this bud grows sufficiently long to about a foot in length it is advantageous to pinch away the top. This will enable the shoot to branch out. To help these branches to grow vigorously the tops of the branches above the growing bud may now be cut back to about four inches beyond the budding point. These stubs may be finally removed when the new shoot has established itself firmly and the danger of its being damaged or broken is passed. With old trees the grower has to be very careful. If they are not in good condition it is best not to attempt to renovate them. Such trees have to go and make room for new plants. In dealing with old trees selected for top working it is a good plan to work the top in two instalments. To begin with the tops of about half the number of branches should be cut off and when new shoot spring up a few selected ones should be allowed to grow and the rest removed and these should be budded on when they get fit for the operation. The branches left over serve the useful purpose of providing the necessary shade to the part treated below. After the shoots grown from the inserted buds have grown sufficiently strong and need little protection, these branches may be taken up for a similar treatment.

Soil Requirement:

Almost all citrus varieties can be successfully grown on a wide range of soils but at the same time they are very sensitive to uncongenial soil conditions. The nature of the Sub-soil more than that of the surface soil is the determining factor. A clay soil can be corrected by the addition of humus and sand; and a too sandy soil by the

addition of clay, but it is always nearly impossible and never economic to correct a bad sub soil.

(1) Citrus fruits are very sensitive to poor drainage and therefore they do not do well where the soil is heavy clay of great depth and subject to water logging.

(2) A hard pan, or a hard Sub-stratum within five or six feet of the surface preventing easy drainage or obstructing root penetration is not suitable.

(3) Shallow soils which are very sandy should be avoided as being too open and therefore subject to easy percolation. There is ranger of the finer praticles of soil being removed and much of the easily soluble fertilizers lost by irrigation water.

(4) Shallow soils with 'chaudu' (a whitish limy soil which does not lend itself for easy percolation of water) are unfit for citrus.

(5) Citrus trees are very sensitive to alkali in the soil. All alkaline soils are therefore ruled out for citrus cultivation.

(6) Heavy soils if properly drained are capable of producing good crops but cultivation in such soils is both difficult and costly.

An ideal soil for citrus culture would be a loamy soil of good fertility and of uniform texture such as are found on the banks of rivers with a depth of about 6 to 8 feet. They can be successfully grown if the surface soil is good garden soil, with a fair proportion of sand so as to open it up and the sub-soil capable of retaining moisture and perventing leaching. Medium black soil three or four feet in depth with a pervious 'muram' sub soil usually provide these conditions. A high lying site is always preferable as there is less danger of water stagnation during rains.

Citrus trees are also highly sensitive to excess of moisture at the roots. A high water table within six feet from

the surface will make the site quite un-suitable for citrus if it happens to be permanent as in the case of lands under canal irrigation. Temperory high water table conditions during the rainy season also does considerable damage to citrus trees.

Irrigation water for citrus must be free from alkali especially Sodium Chloride. Excess of calcium carbonate also is harmful.

It is therefore, necessary in the best interest of the Orchards, for the grower to get both his soil and water analysed by competent people and their advice taken before planting his trees. The nature of the sub soil easily be found out by digging pits in different parts of the chosen site. The opinion of experts in the line is always helpful in preventing losses.

Location and site:

The choice of the actual place where to establish a plantation is determined by the location and the site. By location it is meant the position of the place on the map. The site is the particular spot in the location upon which the trees are planted. It comprises the exposure of the place, the dips and elevations and the other topographical features of the place. The location should be chosen with reference to the market and to the weather conditions. Wherever possible it is advantageous to locate a plantation in the proximity of large town which provides an assured market. The facility of a near market is however day by day becoming less important owing to the rapid development of transport facilities. But in this the cost of haulage from the growing to the clearing centre is an important consideration. As regards weather the location should be such that it will meet the requirements of the citrus varieties grown. Exposure to high winds, liability to rains at blossoming time, frost, must receive careful thought by the prospective grower. The site for a plantation in a locality subject to frost should be on elevated or sloping ground to permit the escape of cold air. The nearness of large quantities of water also helps to raise the

temperature of the adjoining lands and exerts a useful influence in the prevention of damage by frost.

In regions where there is danger of sun scorch on the trunks of the planted trees, south western exposure should be as far as possible avoided, or the trees should be protected from direct exposure to the afternoon sun by white washing the trunks or plastering them with red orchre. It is also possible to train the heads of the trees in such a way as to provide shade to the trunk. A southward exposure gives bright colour to the fruit.

In places exposed to high winds much damage is done usually to citrus plantation, while a careful selection of the aspect, helps to keep damage by high winds in check. A wind break has always a marked effect in deflecting or checking strong winds. A wind break is, if properly made, useful in many other ways: It protects the plantation from cold, reduces evaporation from the surface of the land, lessens loss by wind falls, prevents the breaking of heavily fruiting branches, protects flower from severe winds and makes the plant grow straighter. It is howeer, not an unalloyed blessing, as it usually harbours insects injurious to the orchard plants, and hampers the proper development of fruit on plant adjoining it, renders the place colder at certain times, gives little chance to trees near it to be as thrifty as those far from it.

Wind breaks should be planted at the same time as the plantation next to the first row of trees. The ground should be trenched sufficiently deep to prevent the roots of the wind break from spreading into the orchard and depriving the trees, of food and moisture.

Prelimanary Cultivation:

Having selected the site for the orange plantation, the land should be ploughed, harrowed and levelled. Unless the sub-soil is equally fertile it is not advisable to turn the top soil under, while ploughing. The soil should always be stirred to a good depth to break up the firm

and compact soil lying below the surface. An additional preparation that has invariably proved of immense value to the future plantation, is the growing of a green manure crop some time before the time of actual planting. For this a leguminous crop like the sun Hemp (Crotoelaria Juncea) or any other suitable kind, is highly useful. The roots of such a crop open the soil lying beyond the reach of the plough, add nitrogen and supply a large quantity of humus. The green manure crop should at about flowering time, roughly nearly six weeks after sowing, be ploughed into the soil. If it is intended to plant in the cold season the land should be got into form during the hot season and the green manure crop sown early in the ensuing monsoon. The green manure will be ready for ploughing in about the middle of August and the land will get ready for planting during the following cold weather. If planting cannot be done at this time it should be possible at the break of the next monsoon.

The Laying out of the Plantation:

When the land is ready for planting the important consideration of the arrangement of the plants in the plantation should be taken up. In the growing of citrus fruits we deal with plants that have to be placed at great distances, and which do not occupy the whole of the land quickly. Some means has to be found for utilizing the intervening spaces to the best advantage during the early years. The entire area has to be laid out geometrically in advance, not only to make the plantation attractive to look at but also to provide for easy handling of the trrees in the plantation. The utility of geometrical system is most pronounced on level ground. On steep lands it is advisable to plant trees on the contours following the grades along the face of the slope. This provides for proper tillage, prevents soil erosion and permits easy access to the area by animals etc.

Planting System:

It is possible to plant trees in many geometrical designs but the more useful systems are:—

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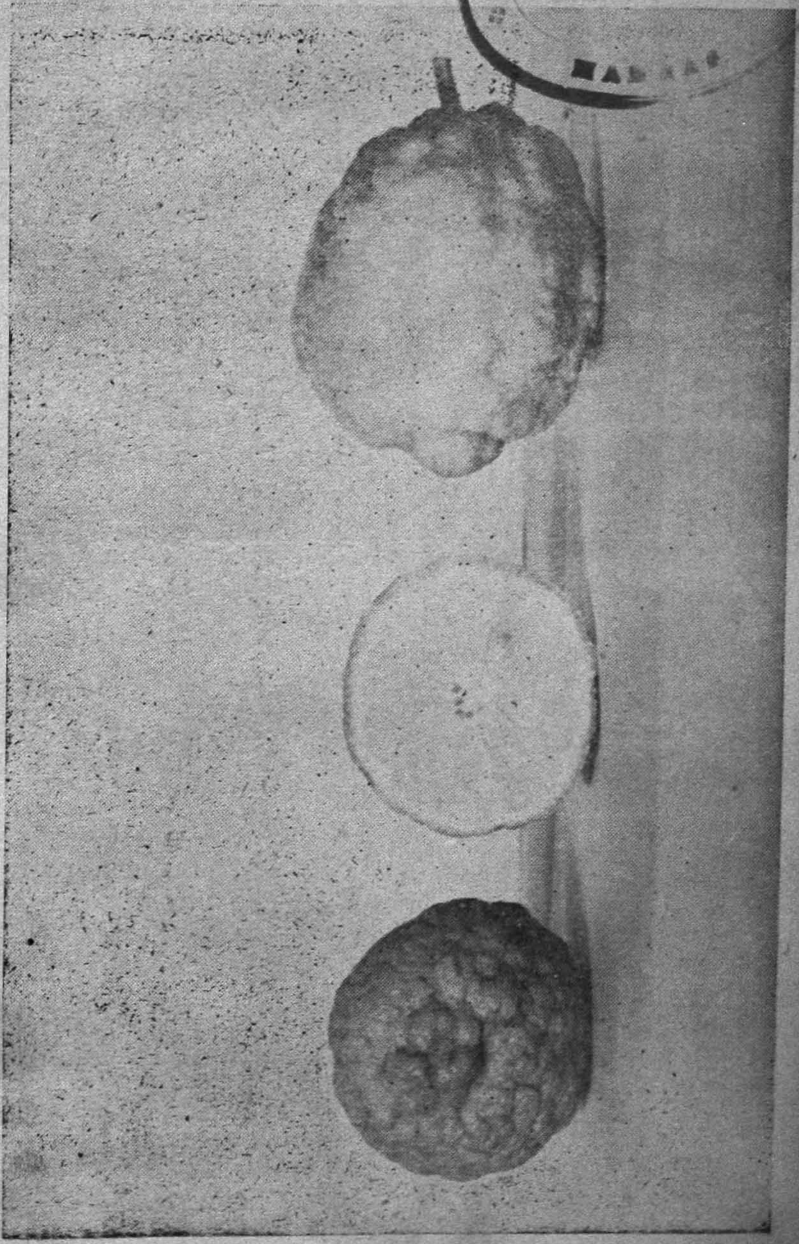

Citron (Maghepal)

The Rectangular or Square System:

By this system the trees set in rectangles either square or oblong. It is the most commonly used of all the systems. The rows of trees in this system intersect each other at right angles and cultivation is possible both crosswise and lengthwise of the plantation. The grower can place his trees at the same distance both ways or plant them closer in the rows than the distance between the rows. This system is easy to understand and easy to layout. If trees are planted by this system, it is better to place them in oblongs and not insquares. The space between the tree rows is greater than the distance between the trees in the same row.

Laying out in Rectangles:

The base line running along one side of the field should be drawn and this is to be the first tree row. On this line the position of each tree at the required distance should be marked by pegs. From the first and the last peg on the base, lines should be laid running at right angles to it. This is either done by the help of a cross staff or by first laying out a triangle with 60 feet on the base line, 80′ and 100′ between the 60′ and 80 feet points, all of which should be marked by pegs. When the tree pegs are in their right positions it is possible to extend the new line to the required distance by means of a rope. On this line the position of the trees may be marked with the aid of a measuring tape. A third line running at right angles to the second may now be laid. It will be easy after this to fix the position of the trees in between the lines at the required spacing by using bamboo poles as guides to connect the pegs of the lines in opposite directions.

Double Planting:

During recent years this system by which two or more kinds of fruit trees are planted in the same areas, has come into vogue in fruit growing areas. In Khandesh, Hyderabad and probably some other places also, grapes,

and bananas are plated in permanent citrus orchards. These crops are removed after about 4 years during which time they yield very appreciable incomes to the grower without seriously affecting the growth of the citrus plants.

—*—

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9 SEP 1959

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